Epistemological Trends in the Literature on Mobile Devices, Mobile Learning, and Learners with Visual Impairments

ABSTRACT: This study is significant because learning with mobile devices is increasing as a method of educating and training learners with visual impairments, but evaluation of its method is rare. In addition, the epistemological model used in this study is designed to improve future research designs. This article reviews the literature on the use of mobile devices by learners with visual impairments in a variety of learning environments. The study's three objectives are to pursue avenues of research in m-learning and visual impairment, stimulate debate on the nature and role of mobile technologies in the education of learners with visual impairments, and develop a debate on the best use of technologies in m-learning. The study uses an epistemological model of visual impairment as an instrument to critically analyze different ontologies and paradigms of research. The epistemological model is also analyzed as an analytical instrument. The study identifies three academic paradigms in this field: (1) conceptual, (2) design and user testing, (3) m-learning in situ. The study also finds these three paradigms ontologize visual impairment in different ways, meaning that there is little cohesion in research and practice. The study finds that research on the development and use of technologies by learners with visual impairments is restricted by a lack of cohesion in theory and practice. This lack of cohesion is thought to be largely due to the immature nature of this topic as a field of study.

INTRODUCTION

This article critically discusses English-medium academic literature on the use of digital, mobile technologies by learners with visual impairments. The epistemological analysis—that is, the analysis of knowledge created through academic documents—in this article focuses on improving learning with mobile technologies, access to education for learners with visual impairments, and the advantages or potential issues of learning with mobile technologies for learners with visual impairments. During the study, the literature was investigated through three phases of analysis. Although the literature within the last 5 years was prioritized, documents before this period were also evaluated to gauge the epistemological development of the literature.

In addition to reviewing the literature, the analysis in this study was also designed to evaluate the epistemological model of visual impairment as an instrument of investigating learners with visual impairments and mobile technologies in educational institutions.[1] The epistemological model of visual impairment is premised on a finding from previous research that inaccurate knowledge about learners with visual impairments stereotypes blindness. These stereotypes lead to strategies of learning where vision is often removed altogether or diminished, and these strategies often have a more negative effect on learning than learners' physical impairments do.[2]

The study has three aims: (1) to discuss avenues of research in learning with mobile technologies and visual impairment, which can inform theories of learning with mobile technologies in educational institutions; (2) to provide the reader with an introduction to the broader debate on the nature and role of mobile technologies in the education of learners with visual impairments; and (3) to debate the best use of technologies in learning with mobile technologies for learners with visual impairments in educational institutions. This study is necessary because numerous mobile technologies have specifically included accessible settings for use by learners with visual impairments, but little understanding of their effectiveness is available,[3,4] although it is also acknowledged that there is a move toward merging desktop, laptop, and mobile platforms, making accessible features, such as screen magnification, font size, and contrast manipulations, universal.

Structure of the Article

This article is broken into the following five sections: (1) the grounded methodology used to analyze and categorize the literature included in the study; (2) the findings from the first stage of analysis, focusing on a description of mobile technologies and strategies of inclusion in learning environments; (3) the findings from the second stage of analysis, focusing on paradigms of literature on the use of mobile technologies by learners with visual impairments, and an initial hypothesis; (4) the findings from the third stage of analysis, which tests the hypothesis; and (5) conclusions drawn from the study.

RESEARCH METHODOLOGY

System of Review

The method of searching literature was divided into two and conducted in late January 2017.

The first search was of theses, academic journals, academic books, and academic conference proceedings that specifically promoted learning with mobile devices in institutional settings; preference was given, although not exclusively, to documents published within five years of the search of databases. These documents were searched for using the following research databases: the U.S. National Library of Medicine, National Institutes of Health's PubMed database; the British Education Index; Scopus; Web of Science; the Institute of Electrical and Electronics Engineers' Explore database; the Association for Computing Machinery's database; and Google Scholar. Other than Scopus and Google Scholar, all academic databases were chosen because they recognized information science, computing and education journals, and conference proceedings. Google Scholar was chosen because it is a general database of documents and could identify journals and conference proceedings from other disciplines not recognized in specialized databases.

As part of this search, it was discovered that a significant number of documents from institutions specializing in the support of learners with visual impairments were reviews by people with visual impairments writing from personal experience. These reviews subsequently supplemented the documents included in the open coding, as they demonstrated the needs of learners with visual impairments discussing learning with mobile technologies from their own point of view.

The first search returned n = 74 investigative documents, and this number of documents was then reduced to n = 38 typical documents. These documents were verified through a double-blind peer review of their abstracts by colleagues with expertise in this field, who considered their focus and relevance to those working with learners with visual impairments. The peer reviewers considered the following criteria to select documents: mobile technologies are at the center of learning; learning takes place in institutions, preferably as education or training; learners should actively include learners with visual impairments; studies should include empirical evidence as either primary or secondary source literature; documents published within the last 5 years should be prioritized; and the more subjective issue of the overall academic quality of use of the study should be considered.

The second search was of institutional literature; this included literature produced by well-known English-speaking charities for people who are blind and visually impaired in the United States and United Kingdom that have links to governments and produce literature as guidance for learners with visual impairments, such as reviews of software, reports of new hardware, and lists of useful apps. Commercial website institutional literature, the trade press (including official recommendations and reviews of mobile technologies), and websites of mobile technology companies were also searched using a regular Google search engine. This second search was for definitions referred to in the documents' key words and key phrases, which provided a benchmark for holding the studies in this literature to account. Eventually, five terms were found to appear in most literature on learners with visual impairments and learning with mobile technologies: blindness, visual impairment, assistive technology, inclusion, exclusion (most commonly referring to social exclusion as a result of maleducation), and inclusive technology.

During both searches, combinations of the following key words or key phrases in two different categories relating to visual impairment and mobile learning were used: CATEGORY A KEY WORDS, including visual impairment, blindness, blind, reading impairment, reading disability, and visual disability (these were identifiers of visual impairment), and CATEGORY B KEY WORDS, including m-learning (a jargon term used for learning with mobile technologies), mobile technologies, mobile learning, tablet technologies, smartphones, apps, educational technology, and learning technology (these were identifiers of mobile technology and learning). These key words were adapted from previous literature searches in related fields of study and familiarity with the language used in this field of study[5] (N.B., it was decided not to use commercial or brand key words or key phrases, such as “iPad” or “iPhone”). Each key word from CATEGORY A was combined with each key word from CATEGORY B and separated by a Boolean “AND,” meaning that documents had to contain at least a key word from each category. The results of these searches by database showing how many documents were discovered are displayed in Table 1, and the chosen academic documents by the databases they appeared in are shown in Table 2. These tables indicate the quality of the databases for providing relevant documents.

There were restrictions to this method of sampling literature that made it an imperfect science. For example, it was observed that some databases used different search algorithms. This provided potential inconsistencies in key word searches. It was also observed that there is no definitive database of all information science, computing, and education literatures. Therefore, it was assumed that some lesser-known journals, conferences, and publishers were potentially missed. There were exceptions to this issue. For instance, although generalist journals on visual impairment, such as the British Journal of Visual Impairment and the Journal of Visual Impairment and Blindness, were possibly not covered by specialized databases, they were covered by Google Scholar and Scopus. However, journals with articles including the use of technology indirectly related to educational theory—such as scientific journals that include articles discussing science education—were rarely discovered in the search.

Method of Analysis

The method of analysis was an adaptation of grounded theory:[37–39] the research was conducted using three phases of coding data: open, axial, and selective phases; data were analyzed in a progressively more focused way during these three phases, and the research regarded all forms of data as equally important. This system of data collection suited the reflexive, problem-solving approach to this novel cultural context and topic. However, unlike the grounded theory, this method encouraged the evolution of culturally deduced theories in the style of Geertz's[40–43] cultural anthropologies and used deductive rather than inductive logic.[5]

TABLE 1. Outline of selected articles after peer review by commercial/ institutional and academic literature by database Commercial/institutional literature

Implementing the Three Phases of Data Analysis

During the open phase, scientific and legal definitions and research methods were compared.[37] The selected literature largely consisted of official documentation by English-speaking mobile technology companies—to streamline this phase, the analysis was restricted to large companies promoting Apple's iOS and Google's Android operating systems—and institutes and nongovernmental organizations, for example, charities and national institutes that support learners with visual impairments. This analysis identified initial, critical issues, such as the disparity between different academic disciplines. During this phase, categories of behavior, objects, and learning environments examined in the literature were also identified, and patterns that linked these categories were examined. This provided a focus for identifying paradigms of literature. Also, during the open coding, research and other scholarly literature and the links they contained were defined and reviewed to determine latent patterns that determined the conceptualization of learning. The initial nature of these patterns and whether they could become classifications were then established.

During the axial phase, links between the literatures within individual paradigms were made, and the meta-analysis of these paradigms was developed into a testable hypothesis.[37] During this phase, literatures that did not seem to be initially relevant or that did not provide latent patterns were filtered out, although these literatures were not rejected altogether and stored for future use. Eventually, the sorted literature was again compared within its paradigms according to whether the type of study was theoretical, experimental, observational, or reflective. From this categorization, more refined meta-concepts and latent patterns that related to all the paradigms were identified. In addition, further links between research, conceptual, and review documents were acknowledged and refined, and more general findings were identified. These paradigms were then recompared with the existing literature. After this recomparison, potentially false assumptions not supported by evidence were dropped or redefined, and the tentative hypothesis was made more robust.

During the selective phase, the hypothesis was tested and refined against the same literature using explication de text— that is, the careful reading of selected texts in great detail[40]—and refined according to misassumptions or anomalies in the new literature.[37] During this refinement, variables and links were reformulated, and the production was made ready for its initial public reading. In the context of this study, the third phase of analysis was prepared for dissemination through a discussion at the Education and eLearning Conference, September 2017, Singapore. This presentation was an important part of the methodology because it was designed to provoke a critique of the hypothesis, adding a new form of data. These three phases of analysis are illustrated in Fig. 1.

Analysis of the Open Coding Phase

Initial Observations: A Review of Definitions

The initial analysis was of definitions of visual impairment and related terms, such as blindness and reading disability, to compare

the use of these terms. During this analysis, it was observed that authors rarely defined the differences between blindness and visual impairment. In addition, authors only rarely referred to students or tablet users with impaired vision in one or both eyes, or minimal vision in both eyes. The authors of these studies also rarely referred to standard definitions of visual impairment, such as that of the World Health Organization.[44]

Definitions of technology were found to be equally stereotyped, and it was observed that similar definitions were rarely given in the literature. For example, where they were defined, mobile technologies were often described as traditional assistive technologies; that is, they tended to be regarded as separate technologies that separated learners with visual impairments from mainstream users.[6] Furthermore, most of the documents reviewed did not seem to discuss the legal concept of exclusion or the use of technology as a tool of exclusion.[1] For example, discussions on exclusion often featured physical exclusion, such as a lack of access to print or visual interfaces because of visual impairment. Documents also rarely discussed the political or legal implications of social exclusion, such as those given in governmental definitions of exclusion.[45]

Where social exclusion was discussed, authors focused on a different definition of technology and largely referred to their assistive features built into operating systems and apps; these technologies have been referred to as inclusive technology, as they are mass produced, marketed, and cost-effective and do not single out users as impaired.[46] This observation could suggest that traditional assistive technologies, such as braillers and older forms of zoom technology, are seen as increasingly economically inefficient and singled-out people with disabilities.

Furthermore, in the initial reading of the literature, it was found that documents referred to specific levels of visual impairment, such as zoom cameras for low-vision users and screen readers for readers with “minimal” or no sight; for instance, these separate assistive technologies were rarely discussed in the inclusive technology literature. Consequently, in this study, mainstream mobile technologies, such as Apple's iOS and Google's Android technologies, came to be regarded as a different form of inclusive technology. Furthermore, it was also observed that learning with mobile technologies was rarely defined or key worded in articles on learners with visual impairments, despite this phrase being discussed or key worded in mainstream learning contexts.[47–54]

Analysis of Institution and Manufacturer Literature

Mobile tablet technologies that adhere to the definition of inclusive technology are recommended by the National Federation of the Blind and the American Foundation of the Blind in the United States and the Royal National Institute for the Blind in the United Kingdom.[55–59] These recommendations feature the potential of these accessible features for learners with visual impairments "out of the box"; that is, they need minimal or no adaption for use by learners with visual impairments after being sold.

For example, reviews by low-vision users observed screen resolutions of tablets, the improved zoom facilities in these technologies, and the presence of dictation software–improved usability.[57,59] Other reviews also observed that tablet and smartphone cameras were valuable for magnifying more distant objects.[55,57–59] Furthermore, for those who are completely blind and read braille, mobile technologies were recommended for their compatibility with peripheral writing and reading facilities.[57] However, it was also observed that inclusive features increase processor and battery usage to the detriment of speed and performance in learning contexts.[55]

FIGURE 1. Diagram illustrating the grounded methodology process as cyclical. The grounded methodology analyzed data in three phases, with a hypothesis developed between stages 2 and 3. Each phase of analysis refined an understanding of the literature reviewed. The selective coding phase, the final phase in this study, outlined epistemological trends that were guided by academic disciplines. These findings also fed into planning of a future study. The lines and arrows used in the diagram show the chronological direction of the study, with the final arrow from the final selective coding phase and the planning of the open coding phase in a following study.

Institutions working with learners with visual impairments also observed that learners with visual impairments prefer smaller, economical technologies.[57,59] Analysis of manufacturer literature and academic reviews also seems to show that technology companies are actively attempting to make technologies inclusive. It was also observed that manufacturers' own research identified functions that can potentially be of use to learners with visual impairments.[60] Similarly, reviews of mobile technologies regarded mobile technologies as disruptive technologies; that is, these technologies have the potential to change the way learners with visual impairments live, study, and work, and these often seem to be outevolving traditional assistive technologies.[56,58] This observation is supported by manufacturers of mainstream mobile technologies, which have actively worked to include assistive features in mainstream technologies for learners with visual impairments.[4,60]

The themes in the open coding were taken through to the axial phase through a more focused review and categorization of academic literature. In this review, new forms of technology were analyzed alongside research on the use of mobile technologies and learning with mobile technologies in situ.

The Axial Coding Phase

An earlier review of the use of learning with mobile technologies and learners with a range of disabilities observed that academic documents largely covered generalized observations of learning by a range of students, some of which happened to have impairments.[5] Similarly, this review observed that research, review, and conceptual documents also pose a considerable epistemological problem, as little discussion in this literature covers learning with mobile technologies specifically by learners with visual impairments. Subsequently, an initial classification of this literature was made, and three initial paradigms were identified for n = 31 of the n = 38 documents through analysis of research epistemologies: (1) conceptual documents, which discussed the potential use of technologies by learners with visual impairments; (2) documents on the design and user testing of technologies, including literature outlining “proof of concept”; and (3) documents on learning in situ, which attempted to use or evaluate existing mobile technologies in existing educational settings. The nature of these paradigms is summarized hereinafter and illustrated in Fig. 2.

Paradigm 1: Conceptual Documents

Studies in this literature mostly discussed learning with mobile technologies with learners with visual impairments as part of a broader pedagogy of teaching a range of students with special needs, even when they featured the practical needs of learners with visual impairments.[6–9] The conceptualization of these documents ranged from sociological to pedagogical models of learning with mobile technologies, although no cohesive approach or definition of learners with visual impairments emerged overall. By contrast, two documents outlined the concept of learning with mobile technologies and learners with visual impairments only, focusing on reviews of possible uses of mobile technologies as tools to support pedagogical models rather than being pedagogical models themselves.[10,11]

Paradigm 2: Design and User Testing

Studies in this literature followed a traditional assistive technology model, designing and reviewing custom-made hardware or apps.

Furthermore, custom-made technologies in these studies were also more likely to be used for learning with mobile technologies rather than as tools to support learners with visual impairments with other forms of learning. In addition, the mobile technologies featured in this literature provided nonvisual alternatives as interfaces rather than technologies that enhanced low vision. For instance, a small number of custom-made technologies were featured in the literature, which were primarily designed on the three principles that (1) learners with visual impairments would understand information through haptics,[12] (2) technologies support traditional haptic features through inclusive voice apps,[13] and (3) learners with visual impairments understand the interface through voice alone.[14] These technologies were all designed for learning purposes.

However, although engineers saw their technologies as traditional assistive technologies, most technologies were designed as software platforms situated within mainstream mobile technologies. Moreover, most of the technologies analyzed or reviewed— the minority of which seemed to have an explicit educational use—were also integrated into mainstream mobile technologies and primarily relied on sound interfaces.[6,12–20] Only two of these studies discussed the use of existing and native apps for making mobile technologies more generally accessible for learners with visual impairments.[21,22] This could suggest that there is also a trend toward user interfaces independent of keyboards and mouses, based on touch and more intuitive to all users, but especially learners with visual impairments.

Paradigm 3: Learning in Situ

Studies in this literature largely conform to a model of inclusive technology; that is, most documents promote the inclusion of learners with visual impairments using mainstream technologies. Furthermore, although fewer documents in this paradigm discussed adults' learning with mobile technologies, these studies of learning with mobile technologies (what can be called mobile technology andragogy) were more likely to feature support for learning in non–school/college environments, such as museums or hospitals. By contrast, documents on children's learning with mobile technologies (what can be called mobile technology pedagogy) focused almost exclusively on standard learning environments, such as classrooms or training centers. For instance, the main epistemological trend in this paradigm was of mobile technologies providing support for students

in mainstream learning or working environments, independent learning settings, or non–standard but mainstream learning settings.[23–29] Furthermore, documents focusing on learners with visual impairments as a subset of special needs were more likely to discuss universal design for learning in inclusive technologies; these are two models that seem to be mutually compatible. Moreover, the literature in this paradigm often focused on integrated media and communication technologies as a tool of mainstreaming learners with visual impairments, who were a category of students with special needs.[23–25]

After identifying epistemological trends in the three paradigms, an unrefined hypothesis was formed, as follows:

> Studies and evaluations of mobile technologies by learners with visual impairments very rarely define or understand visual impairment in the same way, although competing paradigms—that is, groups of similar types of study—have developed. Therefore, no single epistemological trend has emerged to guide researchers and writers from different fields of study.

This hypothesis was analyzed during the selective coding.

FIGURE 2. A hierarchical map of categories derived from the axial coding phase. The method used to derive these categories was an epistemological examination of abstracts, key words, and titles used in the literature, which were compared with a qualitative instrument of social inclusion. The three primary categories discovered during the axial coding phase's analysis of academic literature includes the following: conceptual documents, design and user testing, and learning in situ. The hierarchy shown also shows subcategories and themes that were partially in common with neighboring categories. The box at the top, labeled “Institution and Manufacturer Literature,” is deliberately separate to symbolize this as a separate study with no individual categories.

The Selective Coding Phase

To test the hypothesis, literature referring only to learning with mobile technologies and learners with visual impairments—and specifically documents referring only to visual impairment and not visual impairment as a subset of special needs—was reviewed. This selective coding used a grounded theory technique termed explication de text; this is described as rereading the text in detail to compare microtrend and meta-trend within and between documents.[39] This analysis provided a more specific focus for the selective coding and allowed a more accurate analysis of data to test the hypothesis.

Analysis of the Unrefined Hypothesis

The selective coding phase seemed to show documents in the paradigm design and user testing rarely: (1) discussed the audience who tested their technologies scientifically or (2) accounted for a population of learners with visual impairments having residual vision. The analysis of their evidence therefore rarely critically evaluated the development of coherent epistemologies of mobile technologies, learning with mobile technologies, and learners with visual impairments. For example, ignoring the literature presented by institutions working with and including learners with visual impairments,[56,57,59] the design and testing literature mostly focused on apps on the assumption that learners with visual impairments would not need visual references.[12–15] This assumption contrasted with the literature in the paradigm conceptual documents, which mainly featured learners with visual impairments as general learners and mentioned perceptual needs less.[9,11]

There was also a significant difference between epistemological approaches to evaluations of technologies by studies in the paradigm learning in situ and those in the other two paradigms. For example, the literature in the paradigm learning in situ most often explored existing mobile settings and apps to support learners with visual impairments in general learning and training environments.[26–36] The literature in this paradigm also rarely assumed learners with visual impairments' levels of vision and focused on the needs of individual learners instead.

Another difference between literatures in these paradigms was that the literature in the paradigm design and user testing tended to focus on mobile technologies as tools of individual learning tasks alone.[12–16] Therefore, unlike documents in the two other paradigms, the literature in the paradigm design and user testing again tended to support a more traditional model of assistive technology.

However, some evidence exists suggesting that the hypothesis needs further refinement. For instance, there is a loose trend in all three paradigms that suggests that the epistemology of assistive technology for learners with visual impairments is slowly moving toward an appreciation of social inclusion.[3] In particular and as observed previously, studies in the paradigms learning in situ and conceptual documents often featured the literature on mainstream mobile technologies used in mainstream environments.[26–31] Similarly, although they emphasized separate technologies, documents in the paradigm design and user testing were more likely to place an emphasis on the design of custom apps in mainstream technologies.[12–16] This would again seem to reflect an epistemological trend for the social and cultural acceptance of visual impairment, and learners with visual impairments are more likely to receive positive social reinforcement from the use of adaptive technology, such as tablets and smart mobile devices.

Consequently, it can also be argued that there is social will to support an inclusive technology model. However, at present, methodologies and studies in documents are still too young to be able to form a coherent paradigm of research in this field to take this will forward.

CONCLUSIONS

The study makes three primary findings: (1) although efforts have been made to strategize and develop a role for mobile technologies for learners with visual impairments, there are still misassumptions about learners with visual impairments in the literature; (2) there are few coherent strategies in the literature on the design, testing, and use of technologies in individual learning contexts, as different branches of academia rarely seem to communicate; and (3) misassumptions about learners with visual impairments make the epistemological model of visual impairment a viable approach for investigating literature on learners with visual impairments and for highlighting differences between academic paradigms, that is, competing theories in the field of learners with visual impairments and learning with mobile technologies.

Although there is a relatively limited literature on learning with mobile technologies and learners with visual impairments, the volume of documents on learning with mobile technologies and mobile technologies as a means of support is increasing rapidly. This rapid increase is due to the improved use of mobile technologies in education and the ubiquitous nature of mobile technologies in society as a whole. Consequently, it is now possible to identify three dominant paradigms of the use of mobile technologies. However, and despite these new paradigms, there is still no focused philosophy of research or a mature conceptualization of learning with mobile technologies in the literature reviewed to bind these studies together. This lack of cohesion is due to the different academic disciplines represented in this review, which have not found a way of moving beyond their own epistemologies and therefore their theoretical paradigms. More particularly, the authors featured in the conceptual documents and design and user testing paradigms were more likely to inaccurately conceptualize learners with visual impairments as having the same impairment; mostly, this literature saw learners with visual impairments as being wholly without sight (see, for example, the article on AUXie).[14] Conversely, the educationalists reviewed in this study made learning contexts too subjective, rarely looking beyond their own students.

Furthermore, the designers and engineers who authored the articles reviewed in this study too rarely regard learners with visual impairments as a largely low-vision community, mostly needing enhanced visual technologies. Instead, they often regard learners with visual impairments as a largely visual group, needing non–visual media, although it should be noted that this observation is not reflected in many modern mobile devices, which feature numerous customizable settings for learners with visual impairments. Most of the literature featured in this review also still rarely contained prior research on the nature of, and diversity within, the definitions of inclusion and learners with visual impairments before discussing their uses of technology.

Therefore, academics conducting these studies often remain out of step with the needs of most learners with visual impairments, favoring traditional models of assistive technology instead. Consequently, unless researchers from different paradigms take a step back and communicate with each other about the needs of learners with visual impairments, we will take longer to develop useful mobile technologies, or pedagogy and andragogy for mobile devices.

Evaluation of the Epistemological Model and Recommendations and Research Methods

The epistemological model of visual impairment, which theorizes that knowledge of learners with visual impairments has a greater influence on learners with visual impairments compared with individual visual impairments, seems largely appropriate as an instrument of analysis in this context. For instance, the findings in the axial coding show how divided and unfocused our understanding of learners with visual impairments is. Subsequently, learners with visual impairments are often provided with technologies excluding them from visual interfaces rather than accounting for their individual needs. Furthermore, the selective phase of study finds that the literature written by engineers designing and testing technologies often stereotypes learners with visual impairments as purely nonvisual. This is reflected in these academics' writing, which mainly ignores discussions on the different forms of visual impairment or the demographics of learners with visual impairments.[6,37]

However, there were three problems with this research methodology that restricted the review and should be rectified in future research. First, the key words and key phrases that were used were felt in retrospect to be too limited and in particular did not discover documents containing commercial key words/key phrases, such as “iPad.” Although this decision was taken as it was intended to research only non–commercial documents, these words and phrases now seem to be used in common academic parlance. Second, it was felt that restricting the database search to a single period restricted the documents that were found. For instance, a number of documents were added to databases later in 2017 that were not initially found in the initial search. Third, it was felt that more databases should have been searched. Although numerous documents were found relating to engineering and education, it was felt that there is a further literature that mentions education in a related academic context that was not included in the initial search results. These points need rectifying in future reviews.

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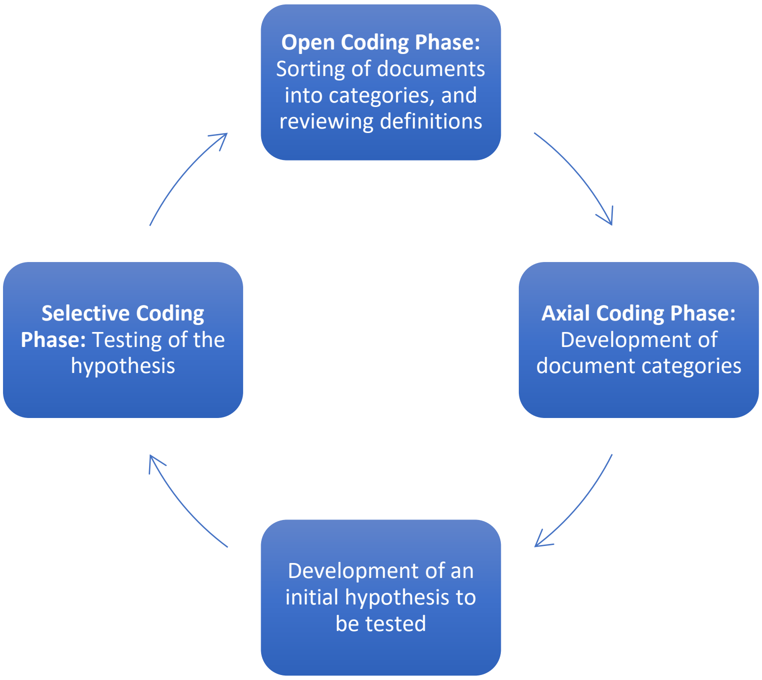
Table 1

Database	Commercial / Institutional Literature		Academic Literature	
	Total Number of Documents Found	Number Included in Analysis	Total Number of Documents Found	Number Included in Analysis
Google	7	6	0	0
Google Scholar	0	0	67	31
PubMed	0	0	7	3
Explore	0	0	7	4
Association for Computing Machinery (ACM)	0	0	9	6
Scopus	0	0	23	19
British Education Index (BEI)	0	0	2	2
Web of Science (Core Collection)	0	0	25	16

Table 2:

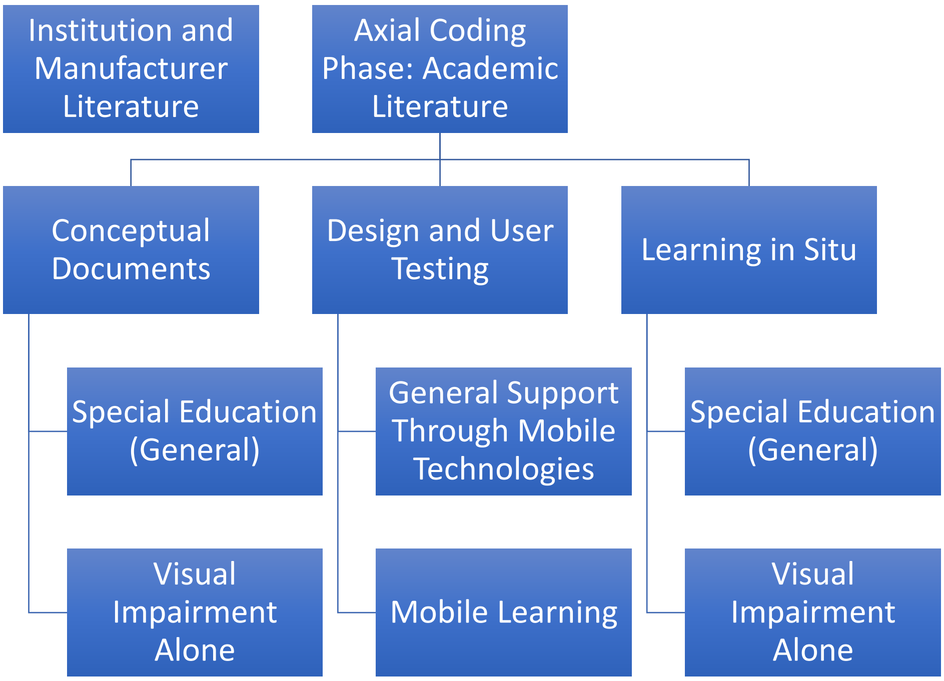
Author	Scopus	ACM	IEEE Explore	Google Scholar	British Education Index	Web of Science	PubMed
Hakobyan L, et. al.[14]	0	0	0	1	0	1	1
Fitzgerald E, et. al.[31]	0	0	0	1	1	0	0
Fernandez-Lopez A, et. al.[32]	1	0	0	1	0	1	0
Burgstahler SE.[33]	0	0	0	1	0	0	0
Edyburn DL.[34]	0	0	0	1	0	0	0
Ashraf M.[35]	1	0	0	1	0	0	0
van der Linden J, et. al.[36]	0	1	0	1	0	0	0
Costa LCP, et. al.[37]	1	0	1	1	0	1	0
Dulyan A, et a.[38]	1	1	0	1	0	0	0
Pesek M, et. al.[39]	0	0	0	1	0	0	0
Santoro C, et. al.[40]	0	0	1	1	0	0	0
Buzzi MC, et. al.[41]	1	1	0	1	0	0	0
Simões D, et. al.[42]	1	1	0	1	0	0	0
Pereira F, et. al.[43]	1	0	0	1	0	1	0
Vitoriano FA, et. al.[44]	1	0	0	1	0	1	0
Keefer R, et. al.[45]	0	1	0	1	0	0	0
Basit W, Sultan N.[46]	1	0	1	1	0	1	0
Istenic Starcic A, Bagon S.[47]	0	0	0	1	1	1	0
Pavlik JV.[48]	1	0	0	1	0	0	0
Hayhoe S, et. al. [49]	1	0	0	1	0	1	0
Kaldenberg J, Smallfield S.[50]	0	0	0	1	0	0	0
Hayhoe S, et. al.[51]	1	0	1	1	0	1	0
Bonifacio VD.[52]	1	0	0	1	0	1	0
Mason T.[53]	0	0	0	1	0	0	0
Rogers N, Draffan EA.[54]	1	1	0	1	0	1	0
Piper AM, et. al.[55]	1	0	0	1	0	1	0
Wong ME, Tan SSK.[56]	1	0	0	1	0	1	0
Hussein AH, et. al.[57]	0	0	0	1	0	0	0
Campana LV, et. al.[58]	1	0	0	1	0	1	0
Thomas R, et. al.[59]	1	0	0	1	0	1	1
Crossland MD, et. al.[60]	1	0	0	1	0	1	1

Figure 1



Open Coding Phase: Sorting of documents into categories, and reviewing definitions
Axial Coding Phase: Development of document categories
Development of an initial hypothesis to be tested
Selective Coding Phase: Testing of the hypothesis

Figure 2



Institution and Manufacturer Literature
Axial Coding Phase: Academic Literature
Conceptual Documents
Design and User Testing
Learning in Situ
Special Education (General)
General Support Through Mobile Technologies
Special Education (General)
Visual Impairment Alone
Mobile Learning
Visual Impairment Alone